

MCAT



UKIRT



Magellan

NASA OPTICAL Measurements

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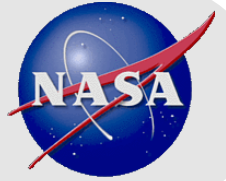
UPDATES

- **Past-year accomplishments**

- Instrumentation repairs: SI camera, Shutter, filter slide
- First break-up campaign through remote obs, Jan 2016
- Telescope fully healthy and ready for obs April 2016
- NASA User Readiness Review held Aug 2016

- **Future goals**

- Installation of 0.4m Benbrook telescope on nearby tower in 2017
- Coordinated observations with MCAT/Benbrook in miniCAT config
- Full testing of autonomous operations, all modes, both telescopes
- Full data collections to commence
- Establish MCAT as contributing sensor for SSN to fill GEODSS gap



MCAT Project Overview

- Dedicated as the Eugene Stansbery Meter Class Autonomous Telescope in 2017
- **MCAT Goal: Statistically characterize under-sampled orbital regimes**
 - Geosynchronous and near GEO altitudes
 - LILO, i.e. Low inclination Low Earth Orbit (LEO)
 - Evening and morning twilight
- **MCAT Objectives:**
 - Monitor and assess orbital debris environment by **surveying, detecting**, and **tracking orbiting objects** at:
 - LEO, MEO, GTO, GEO altitudes
 - GEO debris surveys
- **Ascension Island location enables access to under-sampled low inclination orbits and new GEO longitudes**
(7° 58' S, 14° 24' W)



MCAT Operational Concepts (BIG PICTURE)

1. GEO Sweep/ GEO Follow-up:

*TDI mode matches
GEO motion to sweep
GEO longitudes;
follow-up specific
targets for further
characterization*

2. Catalog or Object-of-Interest Tracking:

*Target specific objects
for testing or
characterization*

3. Orbit Scan (LEO mode):

*Define rate track by a
given expected orbital
rate*

4. Stare – Detect – Chase:

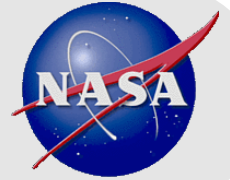
*Object crosses Field
of View, its motion
calculated, chase at
calculated rate of
motion*

5. Coordinated Observations:

**I. Optical-Optical
miniCAT**

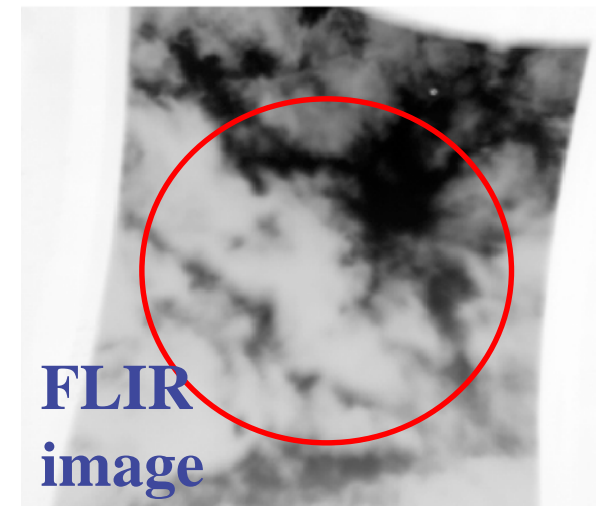
II. Radar-Optical

- **5 Modes of data collection**
 - Currently testing Modes 1-3
- **Survey: Modes 1 & 3**
- **Characterization studies**
 - Mode 2 to determine individual object characteristics/orbits
 - Mode 3 for rapid follow-up after break-up event



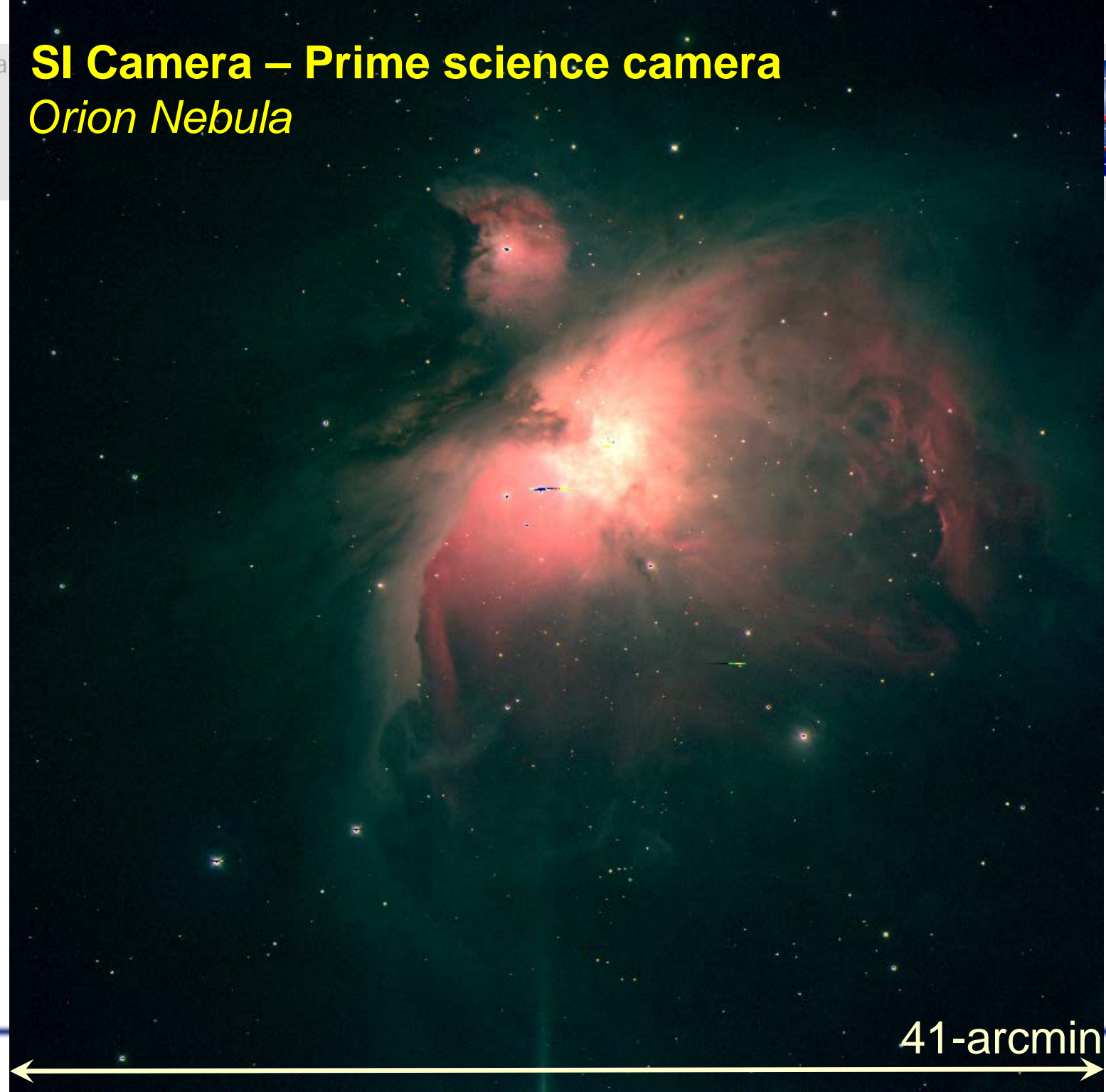
Autonomous Data Collection

- **Automated Data Collection**
 - **Start of Night**: Opens observatory fully
 - **Queries 8 weather sensors** + condensation monitor on primary → open/close
 - **Queries FLIR IR camera** → **sky transparency**
 - Acceptable level set by user or follows default for each observation
 - **Calibration data**: bias, flats, standard stars
 - **Debris data collects** with specified input
 - Filter, Exp-t, # exp, Lunar-angle, Sun-altitude, object illumination, priority etc.
 - **Tracking**
 - sidereal, TLE, user-defined 7-element vector, TDI (GEO survey), HA, RA rate
 - Simultaneous/coordinated obs with miniCAT telescope
 - Same modes, different filters possible
 - Using SGP4, SDP4
 - **End of Night**: Closes observatory fully



SI Camera – Prime science camera

Orion Nebula



41-arcmin

MCAT Sidereal Tracking

Standard star field: Landolt 99_438



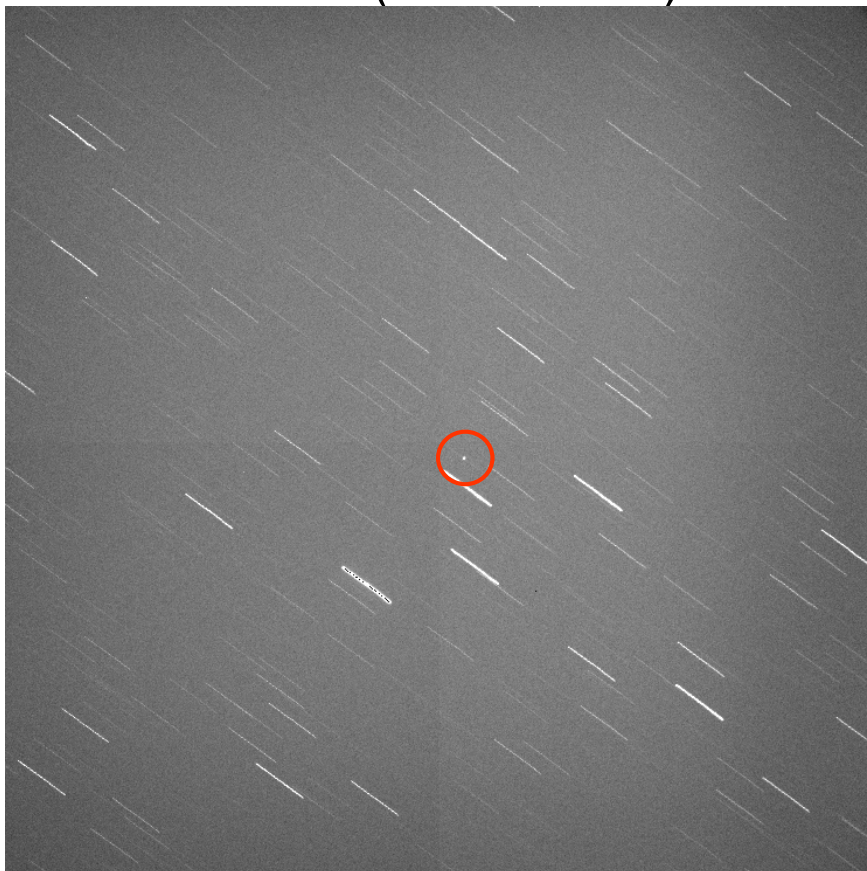
GEO cluster, stare mode



- Tracking at the rate of stars

MCAT Object Tracking (TLE)

MEO (SSN 41019)



GEO (SSN 27389)



- MEO, GEO object tracking with MCAT

MCAT Object Tracking (TLE)



LEO tracking (SSN 40062)

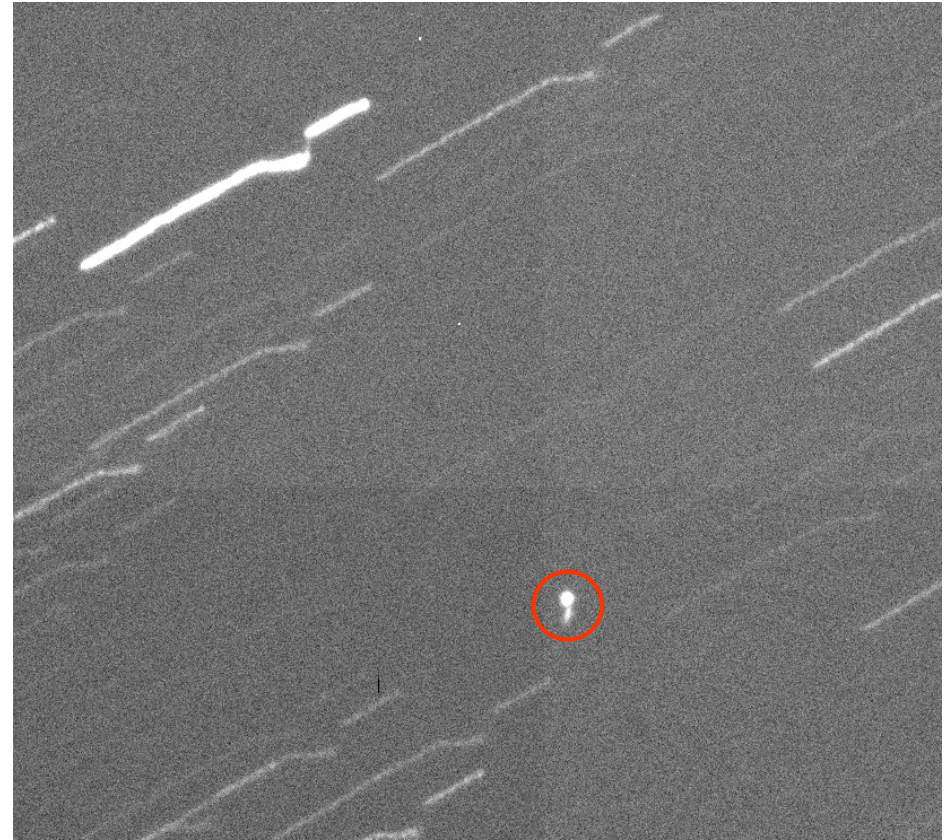


- LEO object tracking with MCAT

MCAT Object Tracking (TLE)

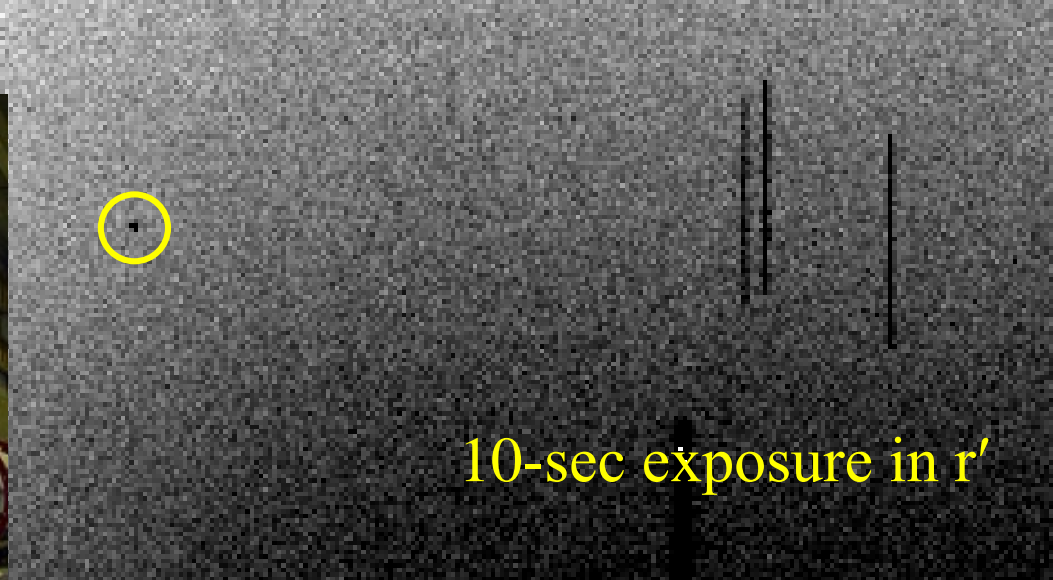


LEO tracking (SSN 40062)



- LEO object tracking with MCAT
- We think we've resolved this!

BRIZ-M Rocket Body Breakup Identified in 2016



- Broke up ~1 month after launch
- Inserted into GEO orbit
- MCAT observed in 2016, shortly after break-up was publically announced



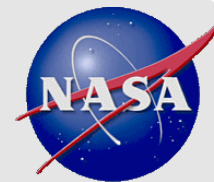
0.4m Telescope

- **Raven-class system design**
- **Instrumentation**
 - 0.4m Officina Stellare telescope
 - LEO tracking Astelco mount
 - Finger Lakes Proline camera
 - $2048 \times 2048 = 44' \times 44'$
(vs. MCAT = $41' \times 41'$)
 - Also very sensitive e2V CCD
 - 1.3" per pixel (vs. 0.6"/pix MCAT)
 - 10-position filter wheel
 - Sloan g' r' i' z'
 - BVRI
 - Matches MCAT
- **DIMM or miniCAT Configs**
- **Simultaneous observations with MCAT in 2 filters!**





MCAT Timeline



New since last meeting: in bold

Systems Testing

- July 2013: Telescope testing
- Aug 2013-June 2014: Software/Hardware integration testing

Construction

- Sept 2014, Ground-breaking
- Sept-March/April 2015: Main facility construction
- March-April 2015: Dome installation
- April-June 2015: Telescope installation

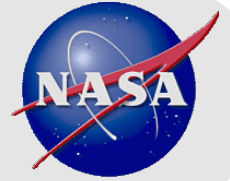
Acceptance Testing

- June 2, 2015: Engineering First light
- June 17: Camera failure
- SAT for all except Camera-specific tasks
- Aug: 1st Light alt camera for debris tracking, lightcurves
- Nov: SI Camera fix
- Dec 2015: SI Camera

Full Integration/ Data Collection

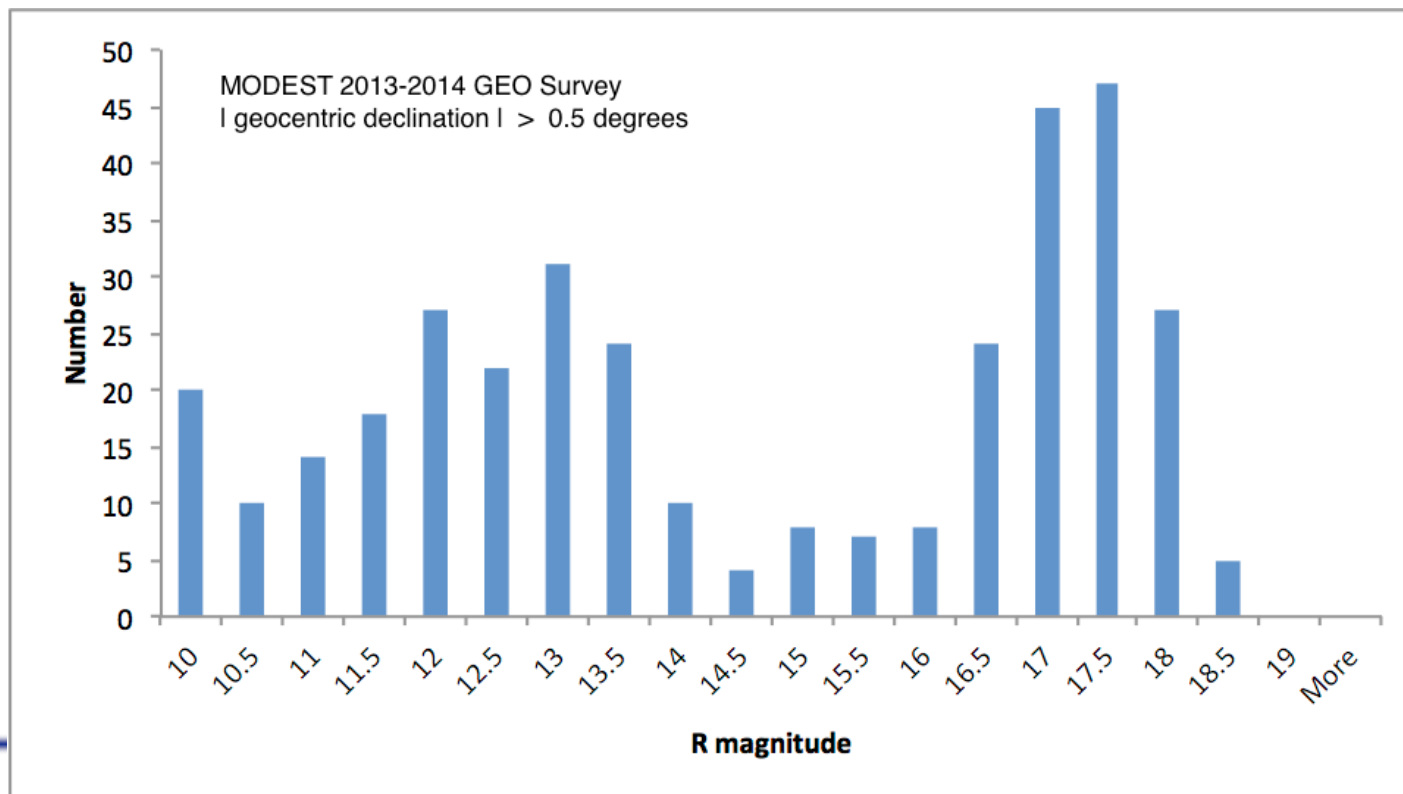
- Jan 2016: Remote Data collects possible
- 2016: Begin MCAT integrated systems testing
- **Aug/Nov 2016: URR**
- **2017: 0.4m scope install**
- **Full operations expected 20+ years**



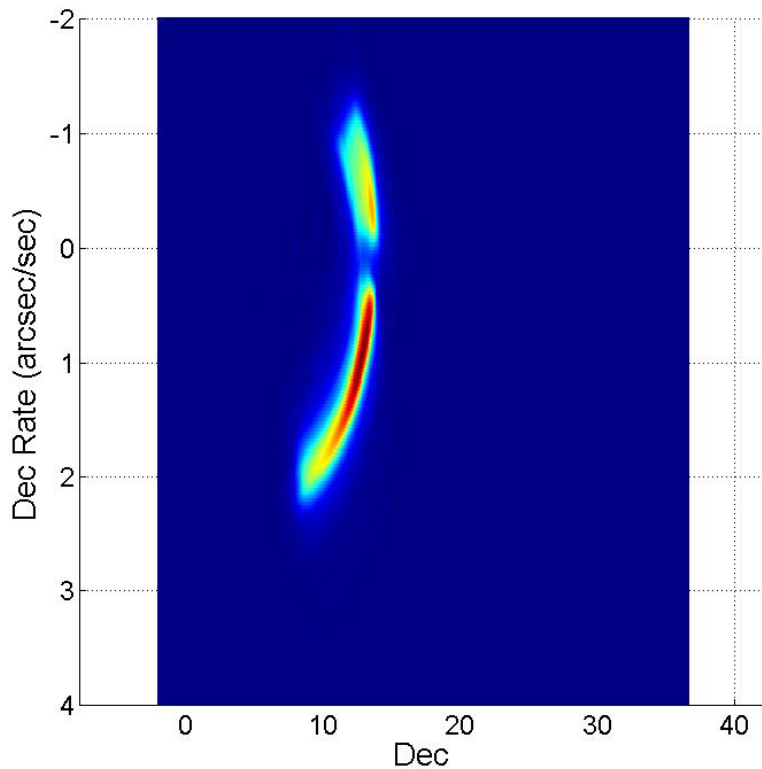


MODEST 2013-2014 GEO Survey Details

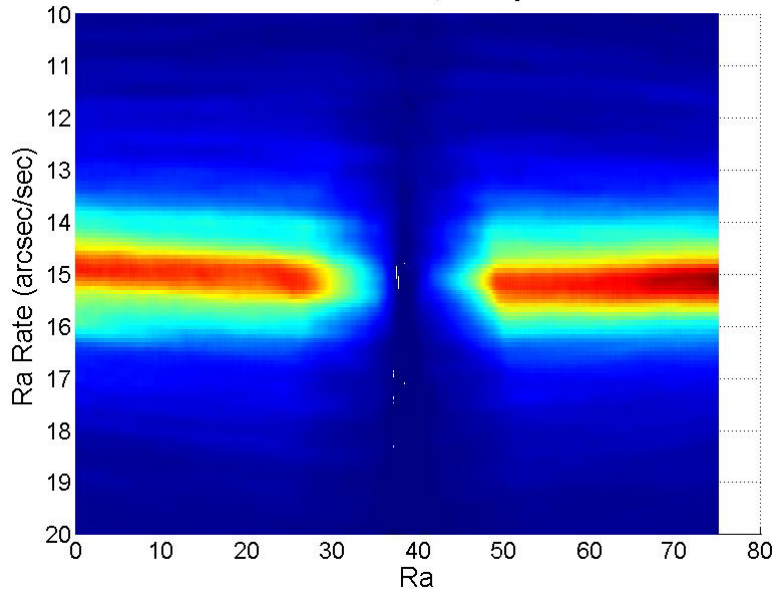
- **Consider fields away from GEO belt of station-keeping objects.**
 - $| \text{Geocentric declination} | > 0.5 \text{ deg}$
- **15 photometric nights total.** July, Dec 2013; Feb, June 2014
 - 351 objects with 4 or more individual detections.
 - 2014 was last year of MODEST GEO survey for NASA.
- **Preliminary Analysis indicates pipeline is working**



3692 Debris Cloud Dec rate Vs UT

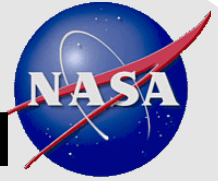


Ra rate Vs RA, all objects

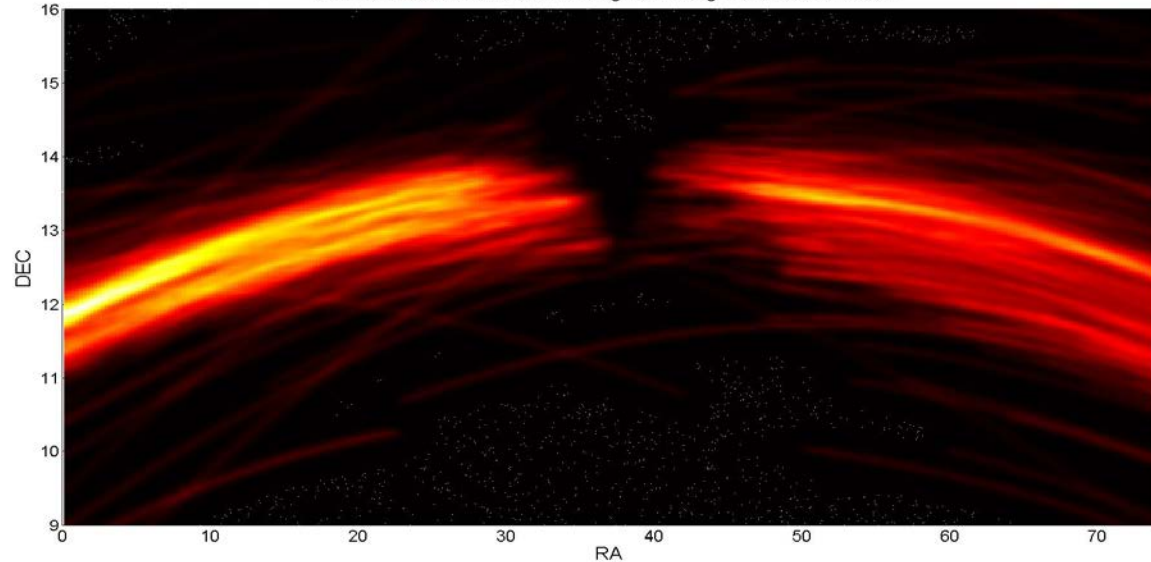


ion

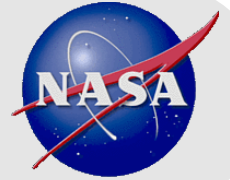
Magellan: 3692 Titan Debris cloud



3692 Predicted Debris > 5cm Over Magellan for Night of UT Oct 31 00-6 UT



- Oct 2015
- 3692 Titan 3C Transtage
- Break-up survey
- NASA Standard Satellite Breakup Model (SSBM) simulated debris cloud



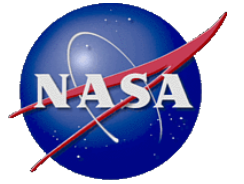
Optical Measurements Center

- **Past- year Accomplishments**

- Spectral measurements/analysis on Titan Transtage samples removed from Transtage while stored in “Boneyard” in Tucson, Arizona
- HS-376 bus study: Spectral measurements/analysis on solar cells (for comparison with telescopic data)

- **Long-term project goals**

- Continuous acquisition of broad-band lightcurve data and BRDF measurements to support characterization of orbital debris.
- Database to include photometric, spectroscopic, and other physical data measurements.
- Develop optical Size Estimation Model (OSEM) comparable to the existing radar-based SEM from DebrisSat fragments



UKIRT

United Kingdom Infrared Telescope
Mauna Kea, Hawaii





United Kingdom Infrared Telescope (UKIRT)



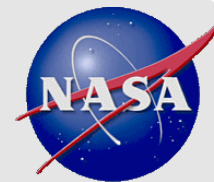
30+ years of operations supporting advanced astronomical science.

- **UKIRT**
 - **3.8 meter telescope**
 - Optimized for near-mid infrared (0.8 – 25 μm)
- **UIST Spectrometer/Imager** 0.85 – 5 μm
Near infrared absorption bands can be used to identify debris materials of spacecraft by modeling with spectral database input

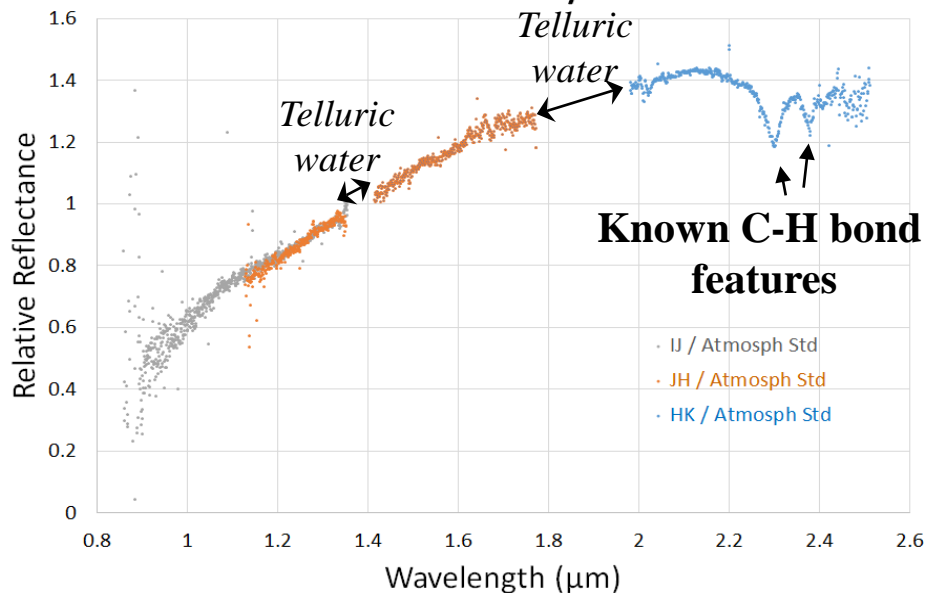


Administration

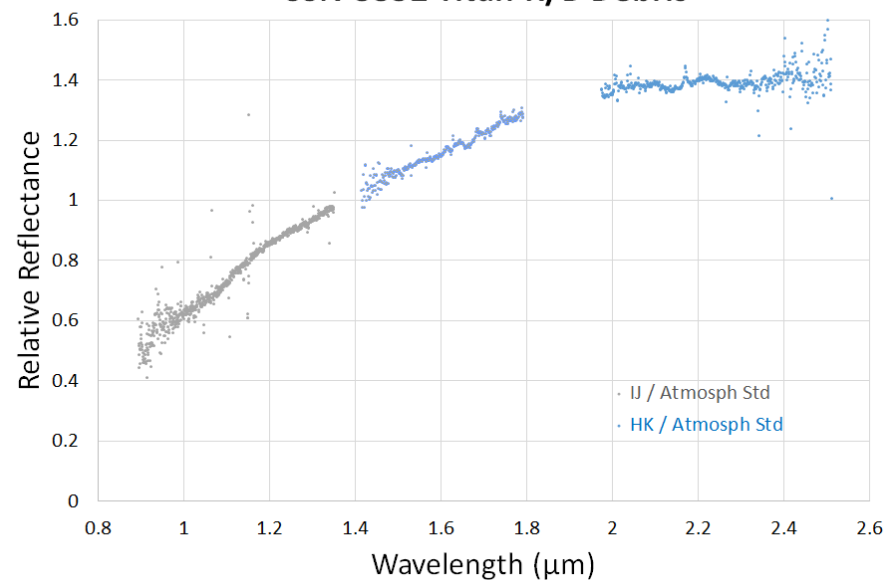
Titan Rocket Body Debris



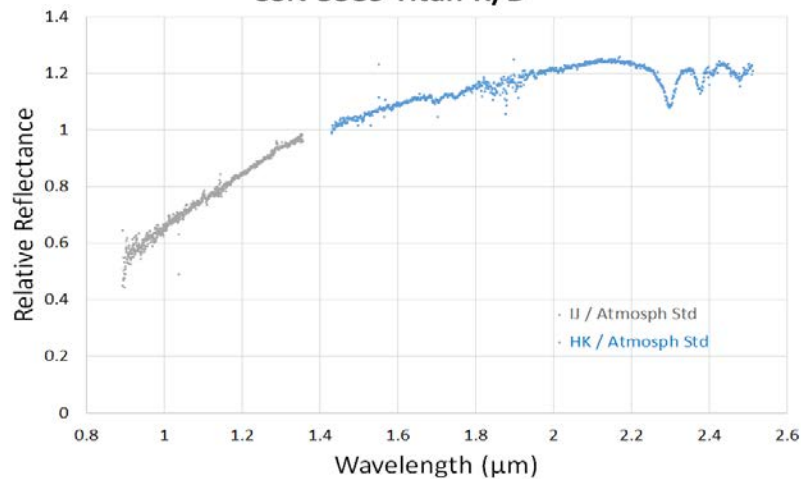
SSN 3692 Titan R/B Debris

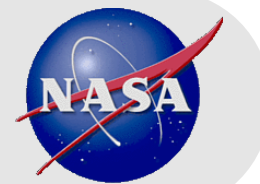


SSN 8832 Titan R/B Debris



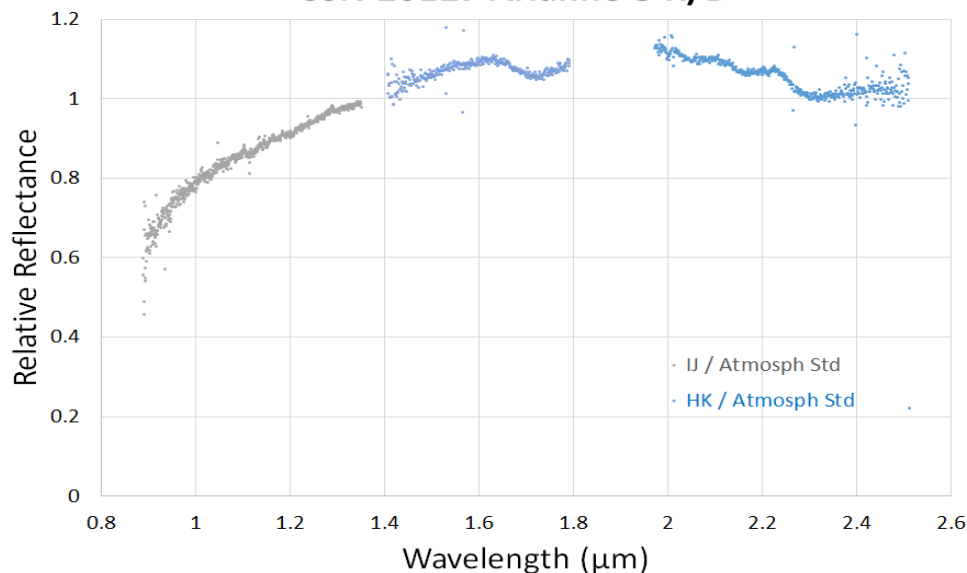
SSN 5589 Titan R/B



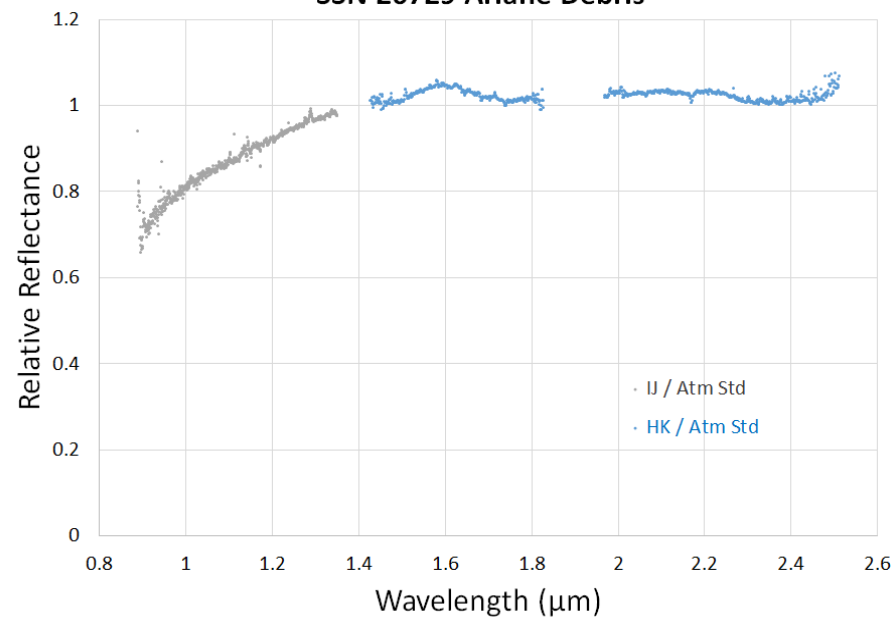


Arianne 2 & 3: in-tacts

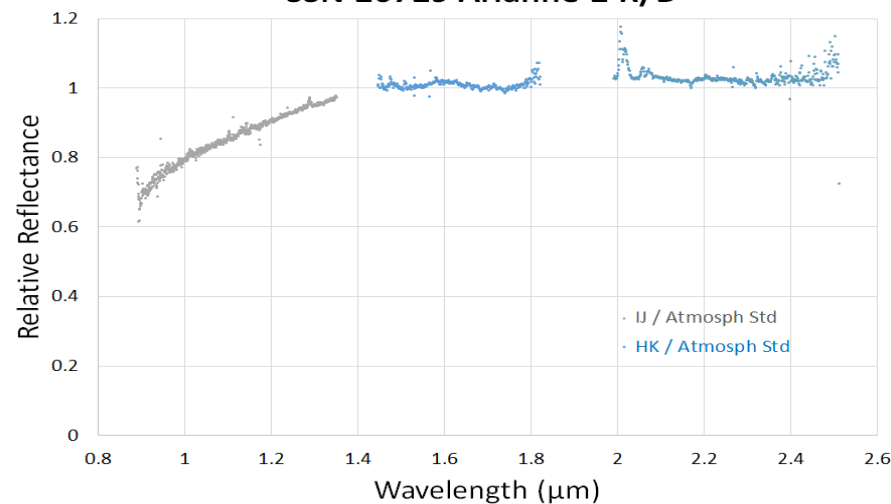
SSN 20127 Arianne 3 R/B



SSN 26729 Ariane Debris



SSN 26729 Arianne 2 R/B



Any Questions?



*Greg Cooke
Photography*

Instrumentation: Weather, Clouds & All-Sky

Weather equipment

- **Weather station/sensors: 5 types (7 total)**

- Temperature, Pressure
- Wind speed average & direction
- Humidity, dewpoint
- Rain sensors
- Cloud sensors

- **All-Sky cam**

- View of the whole sky to determine cloud location and observing strategy

- **FLIR Infrared Cam** (on MCAT secondary mirror)

- Cloud analysis/Photometric Conditions



FLIR
image

Sky Brightness

- Sky Brightness average (no moon): **21.3 – 21.7 mag/sq-arcsec**

Winds

- 17-20mph average sustained winds, SE/SSE

Seeing

- Initial estimates: 1.0 – 1.25"

